Quality and change analysis of forest resource in typical Changbai Mountain forest region

YU De-yong[1,2], HAO Zhan-qing[1*], XIONG Zai-ping[1], WANG Dian-zhong[1], YANG Xiu-ying[3]

[1] *Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang 110016, P. R. China*

[2] *College of Resources Science and Technology, Beijing Normal University, Beijing 100875, P. R. China*

[3] *College of Forest Technique of Shanxi, Taiyuan 030009, P. R. China*

Abstract: The utilization and changes of forest resources were studied in the Lishuihe Forest Bureau. Based on remote sensing images in 1985 and 1999, changes of major forest resources were analyzed by statistical and overlap method and classified quantitatively. The results showed that in recent 15 years, logging spots and man-made young forest changed violently, which was due to human activities. Different forest management manners and harvesting intensity played an important role in forest resources change. Dongsheng and Xilinhe tree farms were typical cases of different forest status and management for the Bureau, where forest succession was intervened by either human or natural disturbance. Dongsheng Tree Farm underwent a light harvest intensity and maintained a unit stock volume of 536.27 $m^3 \cdot hm^{-2}$, as much as that of broadleaf/Korean pine forest of Changbai Mountain Natural Reserve; Xilinhe Tree Farm underwent an intense harvest and was composed of secondary forests, where mature forests just had a small percentage and the unit stock volume was low. The study was useful to guide future forest management. What's more, problems found in the research were also analyzed and reasonable advice was given to the local forest management.

Keywords: Forest resources; Change; RS; Forest status

CLC number: S757.42 **Document code**: A **Article ID**: 1007-662X(2004)03-0171-06

Introduction

As a natural landscape component, forests have the characters of large scope and dynamic regeneration. Natural forest pattern is mainly affected by water, heat. However, with increasing human activity, human disturbances are playing an important role in affecting the distribution pattern of forest resources. As people realizing the multiple multifunction of forest, sustainable utilization of forest resources becomes a fundamental principle. Sustainable forestry is a result of harmonic man-forest system (Yang 2001). Economy and population growth are dominant factors that determine the consumption of forest resources (Dickinson 1986; Feamside 1993; Kaimwitz D 1997; Kleb HR 1999). How to know the utilization, stock volume, distribution and further use of forest resource timely and precisely is a critical issue. In China, forest resources mainly distribute in remote mountainous regions. In the past, they were investigated mainly by manpower with such a long cycle that when a large scope investigation ended, the forest resources had already changed greatly during the period. Remote sensing technology changes this situation, together with GIS, it has been employed in forest resources monitoring (Gao 1999; Han 2002; He & Qing 2003). A number of researches have been carried out in Changbai Mountains since the Natural Forest Conservation Project was launched in 1998. It is of great importance to investigate the quantity, quality of forest resources and analyze its changes in both time and spatial scales for sustainable forestry.

Material and method

Study site

The study was conducted at Lushuihe Forest Bureau (LFB) (127º29'-128º2' E, 42º20'-42º40' N), which is located in northwest slope of Changbai Mountains around Lushuihe river, Fusong County, Jilin Province, and encompasses 12.1 km^2. The average altitude of the area is 600-800 m, with an average gradient of 15º. The climate type is continental temperate. Local vegetation is predominantly midlife conifer and mature broadleaf forest that underwent a heavy harvesting ("large area clear-cut") from 1965 to 1985 and a selective harvesting after that.

Lushuihe Forest Bureau was reconstructed in 1965, and it consisted of eight tree farms. By the end of 1998, it had produced an overall production of 6.37 million m^3, most of which were timber and saw wood. Though scientific multi-purpose utilizations of forest resources were gradually adopted in the Forest Bureau since 1985, former illegal operation had led to large area of irregular logging spots.

Foundation item: This paper was supported by Major projects of Knowledge Innovation Program, Chinese Academy of Sciences (No. KZCX2-SW-320-3)
Biography: YU De-Yong (1973-), male, Ph.D. Candidate, Beijing Normal University, Beijing 100875, P. R. China. Email: ydy@ires.cn
Received date: 2004-05-30
Responsible editor: Song Funan
* **Corresponding author**: Email: hzq@iae.ac.cn

Method

Classification

Landsat TM images of the study area in 1985 and 1999 were interpreted to get the basic information of forest resources. In order to improve classification precision of remote sensing (RS) image, it was necessary to have detailed ground Global Position System (GPS) investigation, know about features of forest resources, and refer to production practices and research results about the region. After the processes of Data Preparation, Geometric Correction, Tasseled Cap, Supervised Classification, Evaluation Classification and Post-Classification Process, the picture including each type of forest resources was mapped. The precision of the supervised classification is 89.97%. Land covers of Lushuihe area were divided into the following 10 types: water body, residential land, logging spot, farming land, wetland, mature conifer forest, midlife conifer forest, mature broadleaf forest, midlife broadleaf forest, and man-made young forest. The classification of land covers was primarily based on their spectral features. Midlife forests were transitional types between young and mature forests. Man-made young forests of both conifer and broadleaf forests were mainly distributed in former logging spots and developed rapidly. They had similar spectral features that could easily be identified in the images.

Cell statistics and image overlap

Raster images are made up by pixels, each pixel cell stands for a special square of different value. The cell is small enough to guarantee analysis in detail. In this research, the cell is 30 m in resolution. On the basis of multilayer input data, the output data was processed by Cell Statistics function. Overlapping of images in two periods was calculated for standard deviation of corresponding cells. Thus the changes of different land covers can be quantified by overlap of major types of the images.

Results and analysis

Land cover comparison in the two periods

Area changes of different land covers during the periods were shown in Figs 1 and 2. These data was derived from transforming the raster data of RS data into vector data.

According to Fig.1 and Fig.2, the increasing types of land covers during the fifteen years were residential land (749.72 hm^2, 248.32%), man-made young forest (+1996.79 hm^2, 25.28%), farmland (+295.47 hm^2, 6.35%), midlife conifer forest (+305.07 hm^2, 3.58%), respectively. The areas of logging spot (-6551.68 hm^2, 88.86%), wetland (-397.67 hm^2, 37.48%), waters (-1397.32 hm^2, 15.46%), mature conifer forest (-2816.14 hm^2, 9.75%), mature broadleaf forest (-3099.52 hm^2, 8.16%) and midlife broadleaf forest (-191.48 hm^2, 1.34%) separately decreased.

The increases of residential land and man-made young forest indicated larger scopes of human activity and increasing man-made young forest intensity. Decreases of logging spot, wetland and waters suggested increase of human disturbance in the region. The whole conditions were that local human activities affected the local ecosystem more strongly.

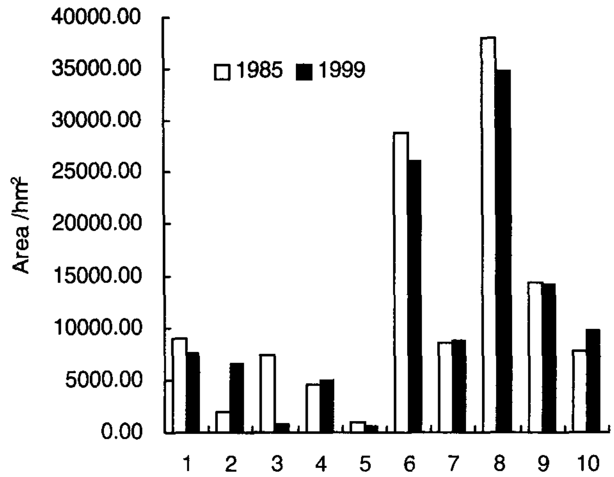


Fig. 1 Area comparison of land covers between 1985 and 1999
Notes: The number from 1 to 10 along the X-axis stands for waters, residential land, logging spot, farmland, wetland, mature conifer forest, midlife conifer forest, mature broadleaf forest, midlife broadleaf forest, and man-made young forest, respectively.

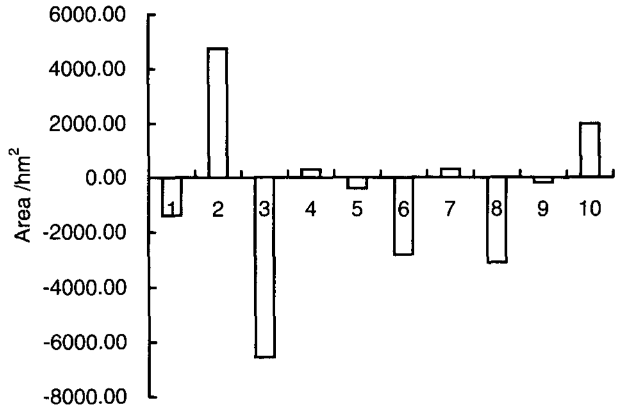


Fig. 2 Area change of land covers from 1985 to 1999
Notes: The number from 1 to 10 along the X-axis stands for waters, residential land, logging spot, farmland, wetland, mature conifer forest, midlife conifer forest, mature broadleaf forest, midlife broadleaf forest, and man-made young forest, respectively.

Analysis of cell statistics and overlap

The calculated results were shown in Fig. 3. Darker color stands for a larger extent of change. Land covers that had a big standard deviation distributed in four oval regions.

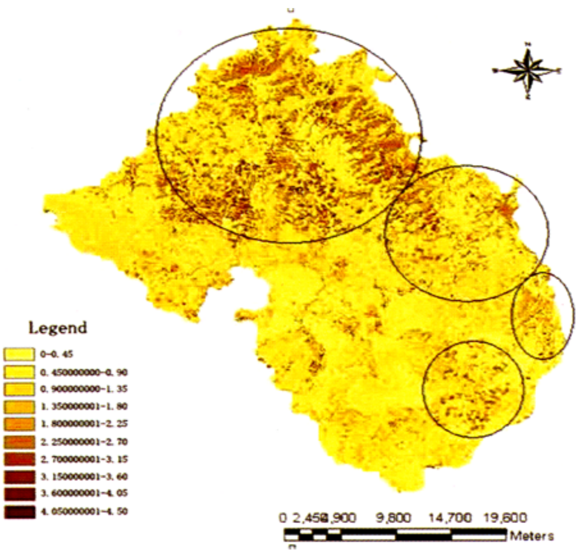


Fig. 3 Standard deviation of land covers among 15 years

To reduce the influence of the same land cover with different spectral properties and the spectral property standing for different land covers, the change rate lower than 1% were excluded from discussion, and only main changes were given attention to. According to Table 1, 46.9% logging spot turned into midlife broadleaf forest, 22.35% into midlife conifer forest; 23.75% wetland turned into farmland, residential land and other human landscape; a quarter of mature conifer forest turned into midlife conifer forest due to harvest of mature trees and rapid regeneration; one seventh of midlife conifer forest grew up naturally and the other 28% change distributed to mature broadleaf forest, midlife broadleaf forest, man-made young forest, logging spot, due to human activity; 15.98% mature broadleaf forest turned into midlife broadleaf, and 20.94% for logging spot; one third midlife broadleaf grew up naturally; man-made young forest had a least preserving rate (36.96%), the other part turned mainly into midlife forest.

Conclusion can be drawn from the above facts, in the past 15 years: (1) There were notably changes among different land covers, and human management was intense; (2) Natural regeneration of forests was another reason for land cover changes; (3) Illegal management led to unfavorable trends of land cover, for example, wetland was changed into farmland. Wetland provides food and habitat for plants, animals and microbes, thus the decrease of wetland area should be paid attention to; (4) Forests of each type at every age underwent harvest. Some of these harvests are not reasonable, for example, large area of midlife forests turned into logging spots; (5) Forest regeneration was considered during forest management. There were less logging spots and more man-made young forest; field investigation showed a sound composition of tree species, and pure forest was rare; (6) Remote sensing images were the reflection of special moments and lack of process. To understand forest dynamics, other disciplines of sciences should be employed as well.

Table 1 Area percentage transforming from one land cover to the others (%)

Class	Waters	Residential land	Logging spot	Farmland	Wetland	Mature conifer forest	Midlife conifer forest	Mature broadleaf forest	Midlife broadleaf forest	Young growth forest
Waters	95.41	0.00	0.03	0.49	3.01	0.40	0.02	0.10	0.47	0.08
Residential land	0.11	97.1	0.00	0.31	1.71	0.00	0.12	0.22	0.13	0.28
Logging spot	0.93	0.28	13.56	8.43	0.74	1.10	22.35	1.31	46.9	4.39
Farmland	0.48	0.62	0.73	86.49	0.44	4.05	2.64	0.5	1.09	2.96
Wetland	1.81	6.51	0.34	6.9	76.25	0.06	0.77	2.35	4.14	1.24
Mature conifer forest	0.05	0.23	0.45	0.31	0.52	62.33	26.64	0.61	7.09	1.28
Midlife conifer forest	0.14	0.08	4.48	0.36	0.14	14.81	57.43	9.44	7.09	6.51
Mature broadleaf forest	0.18	0.18	20.94	2.62	0.62	1.39	2.34	53.21	15.98	2.27
Midlife broadleaf forest	0.08	0.11	5.97	0.00	0.21	0.35	1.03	33.96	55.3	2.99
Young growth forest	0.07	0.12	0.65	0.79	0.28	2.84	21.31	2.57	34.4	36.96

Notes: Status analysis of typical tree farms

Dongsheng Tree Farm has a key cultivated center of Korean pine, which was built since Sino-Japanese War. Its zonal vegetation was primordial broadleaved/Korean pine forest, which accounts for one third of its total area, and the other two-thirds area underwent heavy harvests. Dominant vegetation in Xilinhe Tree Farm was secondary forest and was a better exemplary case of being good conditions after selective cutting. Thus the two tree farms are representa-

tives of natural and human disturbance.

Xilinhe Tree Farm only had a small percentage of area. There were large non-forest lands in Dongsheng Tree Farm, mature forests were distributed as islands, and young forest had a large percentage.

Forest age was divided into five classes: young, midlife, near mature, mature and over mature. Spatial distribution of forest age in the two tree farms was showed as Fig.4 Canopy density is represented by the ratio of canopy projection area to forest area. Generally, forest could be classified into 4 classes according to their canopy degree, scattered (below 0.2), sparse (0.2-0.4), middle (0.4-0.6) and dense (above 0.7). The spatial distribution of closure degree in the two tree farms was shown in Fig. 5. Statistics data of forest age and canopy degree in both tree farms were shown in Table 2 and Table 3.

From Table 2 and Fig.4, it is clear that the area percentages of young, midlife, near mature and over mature forests in Dongsheng Tree Farm were higher than those of Xilinhe Tree Farm, whereas the mature forest percentage was lower than that of Xilinhe.

From Table 3 and Fig.5, the area of each type of canopy degree in Dongsheng Tree Farm was larger than that of Xilinhe Tree Farm, and the area of forestland was also larger.

Table 2. The area and percentage of different aging forests in Dongsheng and Xilinhe tree farms

Forest age	Dongsehng		Xilinhe	
	Area /hm^2	Percentage /%	Area /hm^2	Percentage /%
Young	5428.50	29.15	2652.99	14.91
Midlife	2486.83	13.35	1578.65	8.87
Near mature	108.60	0.58	1352.22	7.60
Mature	3474.00	18.65	7626.3	42.86
Overmature	6036.13	32.41	3217.94	18.09
Total	17534.06	94.14	16428.11	92.33

Table 3. The area and percentage of the forests with different canopy densities in Dongsheng and Xilinhe tree farms

Closure degree	Dongsehng		Xilinhe	
	Area /hm^2	Percentage /%	Area /hm^2	Percentage /%
Scattered	804.95	4.32	530.82	2.98
Sparse	209.11	1.12	0.00	0.00
Middle	3093.73	16.61	2632.98	14.80
Dense	14224.99	76.37	13795.12	77.54
Total	18332.77	98.43	16958.93	95.32

To obtain the spatial distribution of unit stock volume, classified remote sensing data and forest management inventory data were combined and then divided by area of each type, respectively. Combined with vector attribute table of remote sensing data, the unit stock volume of different types were obtained and shown in Table 4.

From Table 4 and Fig. 6, unit stock volume of conifer forest in Dongsheng Tree Farm was higher than that in Xilinhe Tree Farm, despite that mature forest area was not in advantage. According to local information, a great many of high quality trees of Korean pine were robbed by Japanese during the Sino-Japanese War, and afterward they were also cut to meet the construction of People's Republic of China. As a result, the exiting broad-leaved/Korean pine forest was relatively less in Dongsheng Tree Farm.. In forest management, old growth forest should be protected and artificial regeneration forest should be cultivated elaborately.

Table 4. The accumulation of unit area of different forests in Dongsheng and Xilinhe tree farms /m$^3\cdot$hm^{-2}

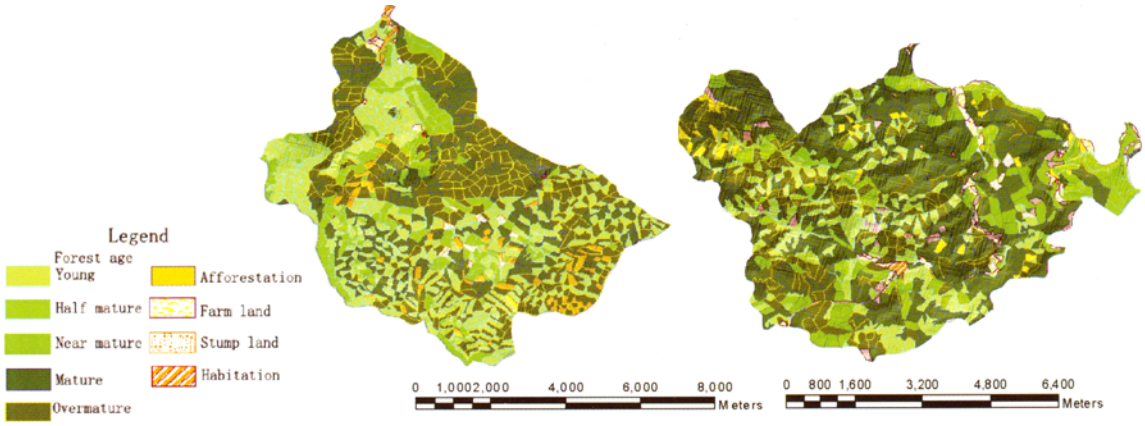
Forest type	Dongsheng	Xilinhe
Man-made young forest	35.82	45.77
Midlife conifer forest	119.62	83.64
Mature conifer forest	536.27	193.35
Midlife broadleaf forest	130.07	172.56
Mature broadleaf forest	262.15	296.60

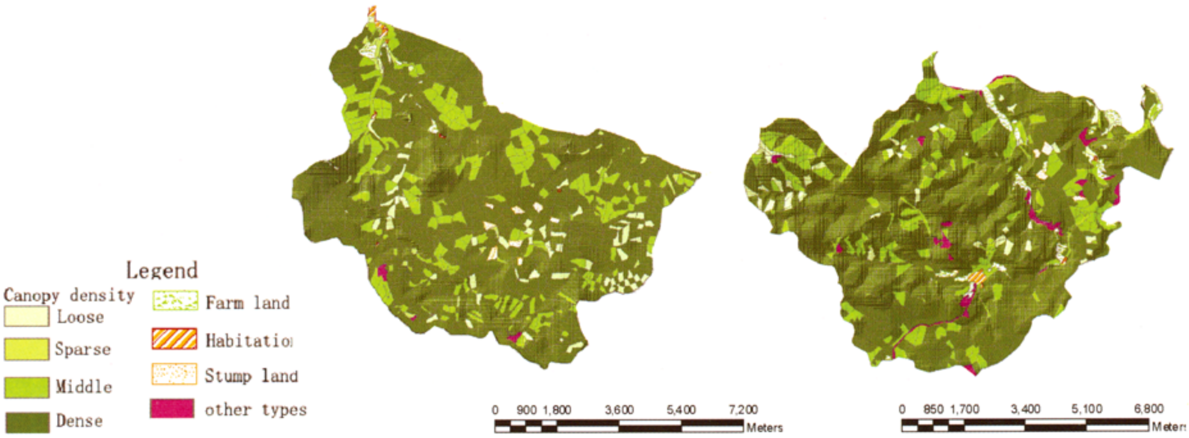
In Xilinhe Tree Farm, years of reasonable management led to a sound structure of unit storage among all the forest age components. However, total stock volume was much less than that of Donghseng Tree Farm. The dominant vegetation should be broad-leaved/Korean pine forest, but broadleaf forests had replaced it. For future forest management, we should stick to selective cut and cultivation to advocate forest regeneration, avoid clear-cut, and pay attention to composition of different species in man-made young forest.

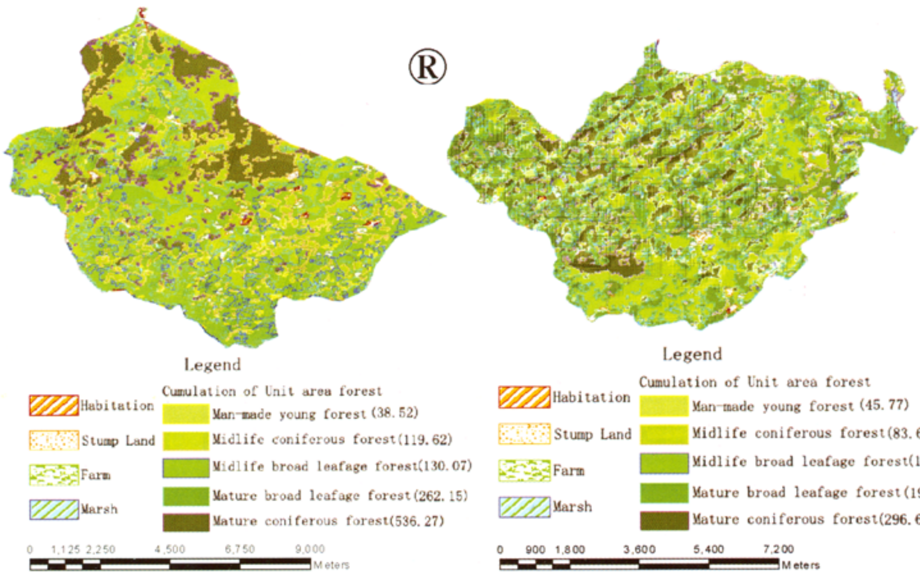
Conclusion and suggestion

According to the data of changes in land covers, during the fifteen years (1985-1999), the area of residential land, man-made young forest and farmland increased significantly. This indicated local human activities had intense influence on the forest ecosystem. The main changes were that the area percentage of mature forest decreased. Human activity was the main factor to cause the change of forest types. Some strategies of forest management might be not reasonable and should be programmed scientifically. In addition, composition elements of zonal ecology environment such as wetland suffered larger environment resistances, with lower area percentage and lower quality conditions. From the conditions of typical tree farms in the study area, parts of forest in Dongsheng Tree Farm have the character of zonal vegetation (broad-leaved Korean/pine forest); its unit stock volume and canopy degree were high, and forest structure was comparatively sound. Forest in Xilinhe Tree Farm refreshed comparatively preferably and was the demonstration base for forest management in Lushuihe Forest Bureau, but unit area stock of the forest was still low, and forest composition was still not stable. According to comprehensive analysis, forest ecosystem in the bureau has already deviated from the stable status of zonal vegetation. So measures for vegetation

restoration should be strengthened. For natural forests, natural cultivation and classified management should be taken, and the emphasis should be placed on holding stabilization of living environment. As to man-made forest, the emphasis should be placed on adoptable and rapid growth species for forestation so as to speed up regeneration in poor sites; while in better sites, it is important to restore broad-leaved/Korean pine forest, and create favorable living environment for the restoration of such regeneration.







References

Chang Yu, Li Yuehui, Hu Yuanman, *et al.* 2003. The preliminary reconstruct of historical forest landscape In Chinese Mountain Natural Reserve [J]. Quaternary Sciences, **23**(3): 309-317. (In Chinese)

Dickinson, R. 1986. The geophysiology of Amazonia: vegetation and climate interaction [M]. New York: John Wiley & Sons Inc, p537-545.

Feamside, P. 1993. Deforestation in Brazilian Amazonia, the effect of population and land tenure [J]. Ambio, **22:** 537-545.

Gao Zhiqiang, Liu Jiyuan, Zhuang Dafang. 1999. The research of Chinese land use/land cover present situations [J]. J. Remote Sensing, **3**(2): 134-138. (In Chinese)

Feng Zhongke, Meng Xianyu, Han Xichun. 2002. Establishing China's technology system of multiple resolution power in investigation of forest resources [J]. Journal of Beijing Forestry University, **24**(5/6): 156-159. (In Chinese)

Hao Zhanqing, Guo Shuiliang. 2003. Canonical correspondence analysis on relationship of herbs with their environments on northern slope of Changbai Mountain [J]. Acta Ecologica Sinica, **23**(10): 2000-2008. (In Chinese)

He Yanfen, Ma Chaochun, Zhu Jinghua, *et al.* 2003. The dynamic changes of cultivated land in eastern mountainous area in Jilin Province—Taking Yanbian Autonomous Prefecture as an Example. 2003(2): 246-250 (In Chinese)

Kaimwitz, D. 1997. Factors determining low deforestation: the Bolivian Amazon [J]. Ambio, **26**: 537-540.

Kleb, H.R., Wilson, S.D. 1999. Scales of heterogeneity in prairie and forest [J]. Can. J. Bot., **77**: 370-376.

Qing Lijie, Wang Ning, Zhang Yu, *et al.* 2003. Study on the effect of land use change on the ecoenvironment in the 3-lakes of the Songhua River [J]. J Northeast Normal Univ. (Nat Sci), **35**(2): 80-86. (In Chinese)

Shao Guofan, Dai Limin, Li Yingshan, *et al.* 2003. FORESTAR: A decision-support system for multi-objective forest management in Northeast China [J]. Journal of Forestry Research, **14**(2): 141-145.

Yang Jianzhou, Kou Wenzhen. 2001. Inherence dynamical mechanism and its model for sustainability of forest resources [J]. J Beijing For. Univ., **23**(3): 94-96. (In Chinese)

Zheng Jingming, Jiang Fenqi, Zeng Dehui. 2003. Eco-value level classification and ecosystem management strategy of broad-leaved/Korean pine forest in Changbai Mountain [J]. Chinese Journal of Applied Ecology, **14**(6): 839-844. (In Chinese)